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Operationalizing Sustainability Principles in the Engineering Profession

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ABSTRACT

The engineering profession has responded to the issue of sustainable development in two main ways. It has responded through public policy statements that acknowledge the magnitude of the problem in addition to pledging to steer engineering towards a more sustainable future, and it has also responded more directly through technological innovation. In this paper, these two responses will be explored with respect to the debate on how to operationalize sustainability principles in practical terms. This paper also attempts to provide the rationale for a philosophy of engineering ethics grounded in the notion of sustainable development. It is hoped that this would lead to a revised "social contract" that would enable engineers to engage more actively in political, technical, economic and social discussions and processes.

Keywords: Engineering Sustainability; Technological Innovation; Public Policy; Sustainable Development

1. Introduction

Engineering, perhaps more than any other profession, has an opportunity to contribute to the "nuts and bolts" of sustainable development [1]. However, sustainable development will require a move away from a traditionally isolated engineering design process to one that is not only open but which incorporates a broad set of people into the decision making process. It has been argued that the design process should concentrate more on the development of quality of life and not just on the development of products. As such, the main issue in engineering design would no longer only be the technical outcome but also "who manages the process and how quality of life is defined and agreed upon, taking into account the potential of different technologies [2]". This would necessitate a new model of solving engineering problems whereby individual engineers would be guided to a large degree by their direct interaction with society.

The move towards a more open way of managing this process "would require that engineers develop a new, inclusive and diverse network of relationships with people who they have traditionally thought of as 'outsiders' in the technology development process [2]". This network of relationships could potentially include ecologists, environmental activists, ethicists, social activists, government agencies and members of the public. An open approach to solving engineering problems would, among other things, hopefully open up the exploration of a wide range of non-traditional solutions to engineering problems.

Recently, non-traditional engineering solutions have begun to be recognized as viable sustainable engineering options. For example, one evolving area that is being explored for non-traditional solutions to engineering problems is biomimicry. Recent studies have determined that nature might be able to provide sustainable solutions to engineering problems. These studies have involved investigating novel ways to cool buildings, collect water in the desert, and keep pipes from clogging with scale. As an example of one such study, it has been found that the shells of marine mollusks may be able to provide a sustainable answer to the problem of controlling pipe-clogging calcium carbonate buildup. A snail shell is made of calcium carbonate but the snail can control the size of its shell by releasing proteins that adhere to the growing face of the shell and halt further growth. A commercial product is now being developed to mimic the mollusk's protein use, hopefully creating a biodegradable substance that can be flushed through pipes to remove scale buildup.

This is but one of many examples of how non-traditional solutions to engineering problems can aid in operationalizing sustainability principles in practical terms. As engineers continue to address the difficult issue of putting sustainability principles into practice, it will become increasingly important for engineers to seek alternative solutions to engineering problems. This is particularly important since it is likely that some of these non-

traditional solutions might provide truly sustainable solutions to a wide variety of problems and issues in both developed and developing countries.

In order to facilitate the development of non-traditional solutions to engineering problems, alternative approaches to solving engineering problems is necessary. It has been argued that sustainable development would benefit from a more holistic approach to the study of engineering problems and the subsequent development of solutions to these problems. The widely accepted belief that engineering is just a process to develop and implement a chosen solution amid several purely technical options needs to be confronted. A more holistic approach to solving engineering problems necessitates an awareness of the interactions between engineered and non-engineered systems, the inclusion of non-technical issues, and a system approach rather, than a more traditional "Cartesian" approach [3]. It can be argued that such an approach suggests a need to redefine the boundaries of the problems that engineer's address. As mentioned before, it should no longer be considered sufficient to simply consider a technical system "without wider and deeper consideration of the values and views of a diversity of stakeholders (environmentalists, politicians, the public, interest groups, the media) and the interaction of technology with these different elements in society [2]".

This new approach to solving engineering problems will also necessitate a re-appraisal of the time horizon of technological decision-making. There have been numerous "examples of 'optimal' technical solutions, derived from a narrow, short-term view, which have given rise to unanticipated interactions and outcomes, both socially and environmentally [4]". As part of a new holistic approach, a solution to this particular problem would be "to envision the desired future state of world and derive solutions today that enable that future to be achieved [4]". This process is commonly known as backcasting.

A worldwide transition to a more holistic approach to engineering and business will require, among other things, a need to develop standards and codes of practice which go beyond physical analysis and traditional guidance on strength, efficiency, durability, product functionality, safety, fire resistance, and so on. At present, sets of ethics and values are already embedded in numerous social institutions that directly affect the engineer and engineering practice. These include standards and codes of practice, professional guidelines and legislation. However, in many cases there is a need to add "sustainability values" (such as environmental protection and social justice to name but two) to more traditional values such as efficiency, durability and health and safety. In other cases, there is a need to explain and identify sustainable development explicitly as a goal of both engineer and client [5].

An example of a "sustainability value" that could be added is that "just as engineers apply safety factors in their design to compensate for uncertainties about the strength of their structures, they could also apply safety factors to compensate for uncertainties about the environmental consequences of their projects [6]". It is anticipated that the development of new guidelines, standards and codes of practice that add such "sustainability values" to more traditional values will increasingly become important in the drive to put sustainability principles into practice.

In many cases, standards that were developed as "minimum standards" are sometimes regarded as "maximum standards" by developers and operators at the local level. In addition, these standards are typically "prepared with reference to the prevailing models and values of development of an earlier period and with reference to the narrow albeit 'professional' standards of interested trade and business association and investors [7]". It is common for these interested parties to then use their lobbying power to oppose any increase in the standards that may be desirable to achieve more sustainable development.

It can be argued that standards "in many countries are often premised upon technologies, social preferences and economic conditions of past decades and rarely establish mechanisms to flexibly respond to new technologies and market conditions as they arise [7]". Furthermore, these standards often do not go beyond physical analysis and traditional guidance on factors such as strength, durability and so on. The consequence of this is that these standards "may not only inhibit innovative local initiatives but, in a national context, may serve as impediments to innovation in the marketplace, thereby further constraining local sustainable choices [7]". An example of this is residential development standards that are developed to ensure consistent standards of building safety and public services. These traditional standards are necessary but they are often based upon certain technological assumptions that can discourage the application of more sustainable technologies in local development projects.

As has been mentioned before, engineers have traditionally tended to consider only a fairly narrow set of consequences from their actions and these have been typically limited to the safety dimension of their designs. However, in their capacity as technical experts on whom society relies, engineers "are in perhaps the best position to also consider the wider and more long-term ramifications of their engineering decisions [8]". In order to emphasize this possibility it would be advisable that taking a broader outlook on their work be included as an ethical duty for engineers. In a revised code of ethics or code of practice, engineers could be "ethically required to take into account the particular local contexts for which their designs are intended, the effects of the rapid spread of

their designs throughout the world, and the effects of their work on the variety of human values as they exist in varying forms in different societies [8]".

2. Reconciling the Conflict between the Engineers Duties to the Client or Employer versus a Wider Responsibility to the Environment and the Community

Putting sustainability principles into practice raises the issue of a potential conflict of loyalties for engineers between their duty of loyalty to their employer and their duty of loyalty to the public and the environment. It can be argued that many engineers in large corporations are subjected to a variety of legal and organizational constraints "that do not permit the necessary decision-making autonomy required in order to hold engineers responsible for the societal and environmental risks of technology [1]".

The "received view" sees the engineer, who does not have the complete autonomy needed to be an ethical engineer, in endless disagreement with corporate management, who habitually ends up overruling engineering judgement regarding technological designs because of their continual pursuit of the bottom line. Of course, this is not necessarily always the case but it can be argued that this type of situation nevertheless frequently prevents engineers from putting sustainability principles into practice. The blacklisting, harassment, and firings that often confronts whistleblowers underscores the organizational constraints often imposed on engineers who speak out in the public interest.

It has been argued, however, that the "greening of business and technology policy may be the solution to the seemingly intractable dilemmas the ethical engineer confronts when trying to reconcile business interests with the public interest [1]". Changing conditions in corporate culture might offer the chance for engineers to finally begin exercising what some have called one's "right to be an ethical engineer". Through their codes of ethics, professional engineering societies have begun to make preliminary but nevertheless important commitments to sustainable development. Sustainable development will require "fundamental changes and a restructuring of the relationships between individuals and professions, and between professions, society, and the environment [9]". It has been argued that a new or revised "social contract" between the engineering community and society would aid in instigating these fundamental changes.

In general, the engineering profession as a whole has essentially demonstrated that it is capable and eager to contribute to sustainability. In turn, society has a "responsibility to fulfill its side of the contract by providing funding, state-of the art research facilities" and "appropriate career opportunities conducive to sustainable en-

gineering practices and innovations, as well as providing opportunities for engineers to inform and participate in the decision-making process regarding technology policy [1]".

It is anticipated that if each group truly strives to honor its commitments, then it is possible that a new "social contract" will evolve between the engineering community and society in which ethical dimensions will play a central and guiding role. It is hoped that this new "social contract" between engineers and society would finally allow engineers to practice their "right" to ethical engineering. This in turn could potentially aid engineers in avoiding narrow technocratic goals that frequently result in rigid requirements when only the "bottom-line" is at issue. However, it has been pointed out that the fear is that "despite proclamations that engineers have an ethical responsibility to endorse the principles of sustainable development, questions of just distribution and other questions of equity are often ignored when engineers consider sustainable development policies [1]". A new "social contract", in conjunction with a new philosophy of engineering ethics that is grounded in a non-utilitarian ethic, might be able to largely avoid such problems.

It has been argued that there are at least two viable ethical philosophies which engineers often follow when they take into account their social responsibilities towards sustainable development. One of these ethical philosophies is utilitarian in nature while the other one is more duty-based. An example of a utilitarian ethic "is the widespread and almost exclusive use of risk-cost-benefit analysis in all major technology assessment strategies used by engineers [1]". However, it is questionable whether a wholly utilitarian ethic can support a philosophy of engineering ethics based on sustainable development due to the many ethical deficiencies linked to such risk-cost-benefit methodologies. Two such ethical deficiencies include "the value-of-life problem, and problems of distributive, social, intergenerational, and ecological justice [1]".

The various limitations of the established utilitarian ethical system has inspired the advancement of alternative ethics that could potentially aid engineers in working out how to articulate their duties, obligations and responsibilities for sustainable development. For example, the moral deficiencies of utilitarian ethics have led some individuals to promote a philosophy of engineering ethics that is based on a doctrine of informed consent and not just "utility maximization". It has been argued that "since no engineering project is ever totally free from risk, most engineering projects can and should be interpreted as an 'experiment' on a social scale [1]". Since engineering "experiments" will have an effect on the public, it is argued that the concerns of the public should be explicitly considered in engineering projects and other technologi-

cal progress. This means that the public needs to be informed of all the potential risks in addition to the benefits of a proposed technological innovation and it must in some way give consent [10]. It follows from this "that the moral relationships existing between engineers and the public should be grounded along the lines of an ethic of informed consent [1]".

It should be noted that this "social experimentation model" and its principle of informed consent also has its problems. Nevertheless, it does put forward a workable alternative to the traditional utilitarianism of much of engineering thinking, and it is likely that this alternative "could better ground the social responsibilities of engineers and their commitment to the ideals and practice of sustainable development [1]". Such an approach would hopefully facilitate the development of the previously discussed "social contract" between engineers and society.

If a new "social contract" is created, based in part on non-utilitarian ethics such as the social experiment model, then it is possible that conflicts between an engineer's duties to their employer versus their duties to the environment and society might be resolved. Engineers have usually seen themselves serving three "clients": their clients or employers; society at large; and their profession. If engineers manage to genuinely integrate principles of sustainable development into their designs as well as their attitudes, they might be able to at last satisfy their duties to all three "clients". To their employers and corporate superiors, they could assume leadership roles in the cultural shift toward sustainable development. To society, they could assume "leadership roles in enhancing public perception and understanding of risk, as well as helping to improve the quality of technology-intensive choices in public policy, particularly when it comes to developing sustainable technology [1]". It is likely that all of this would contribute in a very concrete way towards putting sustainability principles into practice.

3. Conclusion

It has been demonstrated that a more holistic approach to engineering solutions is necessary and that this somewhat non-traditional approach needs to be coupled with the development of a new set of more sustainable engineering standards and codes of practice. This paper has also attempted to provide the rationale for a philosophy of engineering ethics grounded in the notion of sustainable development. It is hoped that this would lead to a revised "social contract" that would enable engineers to engage more actively in political, technical, economic and social discussions and processes. This in turn would have fundamental implications for the relationship between technology and society in addition to the people and professions involved in this relationship. Hopefully this would help put sustainability principles into practice and thereby help set a new direction for the world and its development.

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